Expressiveness of the Breast Imaging Reporting and Database System (BI-RADS)

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The Breast Imaging Reporting and Database System (BI-RADS) was developed by the American College of Radiology and is used by a number of computerized mammography tracking systems. The ability of BI-RADS to encode the data contained in 300 mammography reports at the Columbia-Presbyterian Medical Center was examined. BI-RADS was able to encode normal reports and "special masses" (such as lymph nodes) without difficulty. However, none of the general masses and only 17% of the calcifications could be encoded in BI-RADS. The implications of this for the design of mammography databases are discussed.

INTRODUCTION

With the passage of the Mammography Quality Standards Act of 1992, Mammography became one of the first medical domains required by law to track patient outcomes.[1,2] This is not a new trend, the importance of follow-up in Mammography has been appreciated for many years.[3] In order to facilitate this, a number of computer systems have been developed to assist in the task.[4-6] These system all require that the mammography finding be converted into some coded form. Some of these systems utilize the Breast Imaging Reporting and Database System (BI-RADS) as their coding system.[4,7] An important characteristic of any coding system is its ability to express all important concepts in the domain.[8-11] As part of a larger project exploring methods for the encoding and display of mammography data,[12,13] the expressiveness of BI-RADS was examined.

BACKGROUND

The Breast Imaging Reporting and Database System (BI-RADS) was developed by the American College of Radiology (ACR).[7] An important characteristic of BI-RADS is its intended role as "a quality assurance tool designed to standardize mammographic reporting, reduce confusion in breast imaging interpretation and facilitate outcome monitoring". [7] Central to the BI-RADS design was its "top down" development by a panel of experts.[16] It is not simply a system to record mammographic findings in their current form, but it is also intended as a recommended method for improving the quality of mammographic reporting.

The BI-RADS system is composed of four main components:

- A lexicon of preferred terms
- A standardized list of critical mammography findings
- A system for converting findings into short alpha-numeric codes
- A relational database schema for storing and reporting mammography findings

The development of a standard lexicon and the development of recommendations for content of reports have both been significant contributions, not only to mammography, but to medical coding in general.

The BI-RADS system is optimized for the identification and reporting of significant mammography findings on screening mammography. The coverage is significantly less complete with respect to description of the post-surgical breast, or to description of other imaging modalities. The data structure consists of 168 fields. Each field either contains alpha-numeric codes or numerical values. Each finding in a mammogram has a single data record. A single mammographic exam may have multiple records.

The BI-RADS system has changed significantly over its life span. In its 1992 draft form,[14] mammography findings were designated by 3 or 4 letter codes, such as "BCL" for "Benign Calcification Left". These codes are still used by some mammography practices for log book entries.[15] Ironically, the form of BI-RADS that is actually used to manually record findings is now obsolete as a standard, and no longer sanctioned by the group that created it. For this

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Table 1 BI-RADS General Mass Findings

Tabular representation of possible BI-RADS encodings for masses. The base finding is shown in the row headings and the two modifiers are shown in the two groups of column headings (margins and density). Each mass appears twice in the table, once under the margins section and once under the density section. The allowed BI-RADS categories are shown in gray. The added categories are shown in white.

	Margins (1 per finding)						Density (1 per finding)				
Masses	Not Specified	Circumscribed/ Well-Defined	Microlobulated	Obscured Margins	Indistinct Margins	Spiculated Margins	Not Specified	High	Isodense	Low	Fat Containing
Round Mass	1						1				
Oval Mass											
Lobular Mass	1	1					2				
Irregular Mass	1						1				
Mass, NOS		2					1	1			
Nodule		1								1	

reason, the BI-RADS 1992 encoding was not evaluated as a comparative presentation. Instead, we chose to evaluate the 1993 version.

For a project on data encoding and presentation, we needed to encode the information contained in mammography reports from the Columbia-Presbyterian Medical Center (CPMC). If possible, we preferred to use a national standard coding system, such as BI-RADS. However, because BI-RADS represents an expert consensus on how mammography examinations *should* be reported, it was not clear *a priori* whether it had sufficient expressiveness to handle existing mammographer reporting behavior. To evaluate this, a group of mammography reports from CPMC was manually mapped into the BI-RADS coding system, and the results analyzed.

METHODS

The basic BI-RADS structure is a core finding, followed by one or more descriptors. This can be represented in tabular form (Table 1 and Table 2). In the BI-RADS classification system, there are two main types of findings: masses and calcifications. Masses are typed into two groups: "general" masses, which are described by shape, margin and density; and, "special" masses, such as lymph nodes. There are 4 shapes of general masses, 5 margin descriptors and 4 density descriptors. A fully qualified general mass will have a code for the general type and two descriptors. Special masses do not have modifiers. The classification of calcifications is simpler. There are 14 basic types of calcifications. Each of these is described by a distribution modifier. "Legal" BI-RADS encodings are shown in the shaded cells of the tables. When no BI-RADS category existed, additional categories were added on an *ad hoc* basis. These *ad hoc* categories were then available for encoding subsequent exams in the test corpus. The added categories are shown in the unshaded cells of the tables.

To evaluate the expressiveness and coverage of the BI-RADS system, a corpus of 300 mammography reports was collected. These represented all mammography reports uploaded to the CPMC clinical data repository from the Radiology Information System over a period of roughly 2 weeks. These were then manually encoded into BI-RADS categories. Although the coding was manual, there was very little ambiguity about which findings could be coded. For example, one report stated "there is a 1.6cm very well circumscribed dense mass." This mass has margin and density descriptors, and would have notations in those columns of Table 1:

- Margin: circumscribed/well-defined,

Table 2 - BI-RADS Calcifications Findings

Tabular representation of possible BI-RADS encodings for calcifications. The base finding is shown in the row headings and the distribution modifiers are shown in the column headings. The allowed BI-RADS categories are shown in gray. The categories that had to be added to encode findings are shown in white.

Calcifications	Distribution					
	Not Specified	Grouped or Clustered	Linear	Segmental	Regional	Scattered
Skin Calcifications						
Vascular Calcifications						
Coarse Calcifications						
Large Rod-like Calcifications	1					
Round Calcificaitons						
Spherical Calcifications						
Eggshell or Rim Calcifications						
Milk of Calcium Calcifications						
Suture Calcifications						
Dystrophic Clacifications		1				
Punctate Calcifications	1					
Amorphous or Indistinct Cal.						
Heterogeneous or Pleomorphic Cal.						
Fine or Branching Ca.						
Not Specified		2				1

- Density: high.

However, shape is not mentioned and it would be recorded in the "Mass,NOS" (not otherwise specified) row.

RESULTS

Of the 300 mammogram reports examined, the vast majority of these examinations were completely normal, with no significant findings to record. In the positive reports, there were 20 findings: 13 masses, 6 calcifications and 1 associated finding (a skin lesion). The goal was to map these 20 findings into proper BI-RADS categories. Seven of the masses were of the "general" type, and six were "special". As expected, without the need for modifiers, the special masses could all be classified according to BI-RADS terms. The general masses were much more problematic. The mapping of the seven general masses is shown in Table 1. None of these masses could be completely characterized under the BI-RADS coding system. Only 4 of the 7 even fit into the broadest BI-RADS categories.

Calcifications are classified by type and distribution (Table 2). Even though calcifications had only one descriptor, most could not be completely classified in BI-RADS. Of the 6 calcifications identified, only one mapped completely to BI-RADS codes.

DISCUSSION

The lack of a "Not Otherwise Specified" (NOS) category was a significant impediment. In practice, mammographers may not take the time to describe

the appearance of findings in exhaustive detail. They describe the finding in functional terms. Specifically, they often described a finding with terms that conveyed risk of malignancy, such as "benign" or "suspicious". In contrast, the BI-RADS is an appearance-based classification system. This is especially interesting since the cover letter to the BI-RADS manual emphasized the use of assessment categories (such as benign). In spite of this, it is not possible to encode "benign mass" in the BI-RADS system. Similarly, the final form, BI-RADS 1993, could not easily encode the concept of "benign calcification". The system forces all calcifications into 1 of 14 appearance classes (such as "punctate" or "Milk of Calcium").[7] There is no class for "benign."

In the BI-RADS 1992 draft version, short letter codes were used. These resulted in a data structure that could be read by humans. For example, "DNC" denoted "dense, no change. The final BI-RADS 1993 version kept the concept of letter codes, but converted them to single letters and placed them in a large, flat data structure. As a result, codes are no longer easily readable by humans because the meanings of code letters are highly position dependent. For example, "L,S" in fields 67,68 indicates a "lobular spiculated mass". The same two letters in fields 70,71 indicate "large rod-like segmental calcifications". The use of longer, unique codes would facilitate automated data consistency checking.

Because BI-RADS was designed to improve the quality of mammography reporting, one might argue that this reflected deficiencies on the part of CPMC mammographers and not on the part of BI-RADS. Given that the CPMC mammographers come from many different academic centers and training programs, it is unlikely that CPMC reports are somehow unique. It is more likely that the mismatch between CPMC reports and BI-RADS codes reflect the top-down development of BI-RADS. [16] Unfortunately, physicians are well known to resist computer interfaces that force them to say things in one specific way.[5,8,17] The slow rate of penetration of BI-RADS into mammography departments nationally suggests this may represent a significant limitation.

All of this begs the question: how closely should a list of quality control recommendations be tied to a database schema? The design of the BI-RADS data structure links a separate column in the database to each class of term in the lexicon.[7] As a result, only data that fits the BI-RADS guideline *word-for-word* can be recorded. This makes it impossible to record historical data for retrospective analysis. In the same way, the database cannot accommodate changes in the lexicon of attributes or advances in imaging modalities. For example, if it were determined that a third type of descriptor should be applied to masses, a new column would need to be added, necessitating the complete reorganization of a BI-RADS database. In the same way, new imaging modalities, such as MRI, are becoming increasingly important in breast imaging. The inability of the BI-RADS schema to incorporate new modalities may ultimately inhibit its widespread use.

CONCLUSION

Although BI-RADS may represent an idealized goal for mammography to aspire to, it requires extensions in order to completely represent the data contained in mammographic reports at CPMC. To address these needs, we are developing an extended data structure that will be able to store BI-RADS compatible data, but address the limitations we have encountered.

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